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ABSTRACT

Presented is a brief summary of an extensive three-volume evaluation report of the National Science Foundation Comprehensive Assistance to Undergraduate Science Education (CAUSE) program, a program developed to encourage the improvement in quality and effectiveness of undergraduate science education in institutions of higher education. Within this Executive Summary are an overview of the CAUSE program, an evaluation of that program, conclusions of the evaluation, and a discussion of eight recommendations regarding the continuation of the CAUSE program. (CS)

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AN EVALUATION OF THE NATIONAL SCIENCE FOUNDATION COMPREHENSIVE ASSISTANCE TO UNDERGRADUATE SCIENCE EDUCATION PROGRAM

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EXECUTIVE SUMMARY

Prepared for:
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PREFACE

This is a brief summary of a report of a two-year study of the National Science Foundation's Comprehensive Assistance to Undergraduate Science Education (CAUSE) program. The study and its conclusions, although supported by quantitative data, rest heavily on the qualitative analysis of a series of site visits and in-depth case studies of individual CAUSE projects. This analysis occurred at multiple levels throughout the course of the study--during the visits themselves; during the process of writing, rewriting and reviewing site visit and case study reports; during formal and informal meetings of the project staff; and during the writing of the final report which assimilates the analyses of both the qualitative and quantitative aspects of the study. Because this analytic process is subjective by its very nature, we have tried to open it to review through the three volumes of the evaluation report. The reader is referred to the site visit reports and the case studies in particular for an understanding of how we came to our conclusions as well as how the CAUSE program operates in context. The site visit reports and the case studies are an integral part of the study and should not be considered as supplementary appendices.

OVERVIEW OF THE EVALUATION REPORT

Volume I: Overview and Findings

Chapter One, Overview of the Evaluation, contains a description and the history of the CAUSE program and a brief introduction to the evaluation of CAUSE.

Chapter Two, Methodology of the Evaluation, contains a description of the evaluation issues, the framework of the evaluation, data-gathering methods and activities of the case studies, site visits, survey, and analysis of proposals.

Chapter Three, Conclusions, provides conclusions for each of the six issues of the evaluation based on the analysis of data from all the sources (survey, proposal review, site visits, case studies).

Chapter Four, Recommendations to NSF, presents a discussion based on conclusions reached in Chapter Three and provides recommendations to NSF for program modifications.

Volume II: Visits to 25 CAUSE Projects

Chapter One, Analysis of Findings from Visits to CAUSE Projects, presents a descriptive assimilation of the issues based on all the site visit reports and all the case studies.

Chapter Two, Case Studies of Eight CAUSE Projects, consists of eight case studies which describe in-depth the project, visits made over the period of a year and the issues as they emerged over the course of a detailed study.

Chapter Three, Site Visits to Seventeen CAUSE Projects, consists of 17 site visit reports which describe the project, the methodology, and the issues as they emerged at each site.

Volume III: Broad View of CAUSE Projects

Chapter One, The Survey of CAUSE Project Directors, presents an overview of the survey; a discussion of the development of both surveys and the analysis procedures; the conclusions, issue by issue, as they emerged from both surveys taken together; and a detailed analysis of each survey, item by item, together with tabled data.

Chapter Two, Content Analysis of Funded Proposals, discusses the techniques employed in analyzing the 273 proposals funded between 1976 and 1979 and presents an analysis of the results of those procedures.

PERSONNEL ROSTER

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OVERVIEW OF THE EVALUATION

Overview of the CAUSE Program

According to the 1979 program announcement the Comprehensive Assistance to Undergraduate Science Education (CAUSE) program encourages the improvement in quality and effectiveness of undergraduate science education in institutions of higher education. The primary objectives of the CAUSE program are to: (1) strengthen the resources for undergraduate science education components of 2-year and 4-year colleges and universities; (2) improve the quality of science instruction at the undergraduate level; and (3) enhance the capability of institutions for self-assessment, management, and evaluation of their science programs.

Any nonprofit, degree granting institution or consortium of institutions in the United States is eligible to submit a proposal. Program objectives are to be achieved through projects identifying and meeting local science education needs. CAUSE is intended to provide for comprehensive revitalization of an instructional program either within or across departments. Funds cannot be requested for major construction or additional faculty except as required for improving an instructional program. Support is intended to result in improvements which will continue beyond the actual funding period. Grants may be requested for up to $250,000 over a 3-year period. The proposing institution must provide at least one-third of the total project costs.

Any physical or social science discipline is eligible for CAUSE monies as are interdisciplinary efforts in the sciences. Each institution is allowed to submit only one proposal. This necessitates at the institutional level the development of some procedure, formal or informal, for determining which department or group of departments will submit a proposal to the CAUSE program.

Proposals are grouped for review into categories of 2-year colleges, baccalaureate-granting institutions, Ph.D.-granting institutions and consortia. A consortium may be formed for the sole purpose of planning a project which will benefit several institutions. A system of peer review has been established for assessing the proposals. The majority of peer reviewers assigned to read proposals from baccalaureate-granting institutions are themselves members of such institutions. The same is true for the other institutional types. Similarly, biologists tend to be assigned to read biology proposals, physicists to read physics proposals, and so on.

The CAUSE program was founded by an act of Congress in 1975 and awarded its first 59 grants on June 18, 1976. It has just completed its fourth year.

History and Background of CAUSE

Origins

CAUSE is a fairly young program; it is the youngest of the three NSF programs now aimed at improving college science programs (the other two are ISEP, Instructional Science Equipment Program and LOCI, Local Course Improvement Program). However, CAUSE has its origins in the College Science Improvement Program (COSIP) which began in 1967. This was a program whose goal was to broaden the availability of superior science programs in all regions of the United States. Specifically, COSIP was responsive to the needs of 2-year, 4-year and minority institutions to improve their science programs at a time when most grant programs were aimed at the great research universities. In 1973, however, cuts in NSF's budget forced a discontinuation of the COSIP program.

Congressional Mandate for CAUSE

When the National Science Foundation presented its Fiscal Year 1976 budget to Congress in the spring of 1975, no mention was made of any broad undergraduate science program. CAUSE resulted from hearings on the NSF budget by the Subcommittee on Science, Research and Technology, U. S. House of Representatives. The immediate cause was public testimony in which the need for support for the improvement of undergraduate science education was stressed. The 1976 NSF Authorization Act, Public Law 94-86, contains this section pertaining to CAUSE:

> The National Science Foundation is authorized and directed to conduct a Comprehensive Assistance to Undergraduate Science Education program, referred to hereinafter as CAUSE. CAUSE shall have the purpose of strengthening the science education capabilities of predominantly undergraduate educational institutions and departments or groups of departments thereof through awards to four-year colleges, two-year colleges, to the undergraduate component of advance degree institutions, and to groups of such institutions. . .

Purposes and Objectives of the Program

The Committee Conference of the two Houses reviewed the purpose of CAUSE and its potential role within the overall NSF science education program. The Conference Report includes this statement describing congressional intent as it related to CAUSE.

> The CAUSE program, initiated by the committee for the coming fiscal year, will provide a means of strengthening undergraduate science education in

> the Nation's colleges. This program will provide specialized science teaching equipment, science teaching materials, and will offer opportunities for the implementation of new methods of teaching science developed elsewhere, and will permit departments and institutions to develop their own approaches to science teaching. CAUSE will also provide funds for the further training of science faculty and for the addition of new science faculty. Grants will be made on a competitive basis . . . interdisciplinary approaches to teaching of science will be encouraged. Particular emphasis will be placed on encouraging the teaching of science in minority institutions and in two-year colleges.

In the final NSF Appropriations Act of 1976, $2.3 million out of a total budget of $10 million was set aside for 2-year institutions.

The Conference Report does not explicitly define the term "comprehensive". NSF has offered this definition in contrast to its other programs:

> . . . CAUSE, however, offers a comprehensive approach to the improvement of an institution's instructional programs by support of broader, more integrated projects. Therefore, a CAUSE proposal must be built upon the application of a set of coordinated activities . . . These activities are expected to improve science education in a particular department or a larger unit within the institution. (CAUSE Program Announcement, 1978)

In summary, the Congressional intent in establishing the CAUSE program was to: (1) strengthen undergraduate science education; (2) provide integrated and broadly-based science improvement programs at the institutional level; (3) provide for faculty development; (4) encourage interdisciplinary approaches to the improvement of science programs; (5) place particular emphasis on improvement of science education at minority and 2-year institutions.

Description of the Evaluation

In the summer of 1977, the Office of Program Integration at the National Science Foundation invited interested organizations to submit proposals for the evaluation of the CAUSE program among others. The general purpose of the evaluation, according to NSF's

original solicitation, was to elicit information about the needs, implementation strategies, outcomes and potential program modifications as these were relevant at the institutional level. The evaluation was not to focus on NSF's internal decision-making, policies, procedures or selection of awards since these were the purview of external oversight activities.

In responding to the needs and priorities identified by NSF, Development and Evaluation Associates, Inc., designed an evaluation which would: (1) be responsive to the wide diversity in CAUSE projects at the institutional level; (2) be formative in nature, facilitating the refinement and improvement of the CAUSE program; (3) be comprehensive in its scope and at the same time provide detailed examination of a few CAUSE projects.

Out of the issues identified by NSF, we formulated six which we believed would potentially yield the most useful information:

1. To what extent are high priority institutional needs being met by local CAUSE projects?

2. How are the CAUSE projects being implemented? What are their strengths and weaknesses?

3. To what extent is the improvement of the quality of instruction occurring as a result of CAUSE?

4. What is the nature and quality of the evidence and the evidence collection and analysis procedures being used to determine the strengths and weaknesses of individual CAUSE projects?

5. What are the relative costs of the design, implementation, and operation of activities within CAUSE projects, and how do they relate to post-CAUSE institutional support?

6. What policy changes and recommendations should be implemented in the CAUSE program?

In seeking ways to be both comprehensive and provide detailed examinations of some CAUSE projects, we designed a three-pronged evaluation (see Figure 1).

The broad focus evaluation. This component of the evaluation provided information on all CAUSE projects funded between 1976 and 1978. It included an examination of proposals submitted to NSF and subsequently funded and a survey of all project directors.

The medium focus evaluation. This component consisted of one-time only site visits to 17 CAUSE projects in order to provide a look at the projects from the participants' point of view and provide some insight on how CAUSE projects were being implemented.

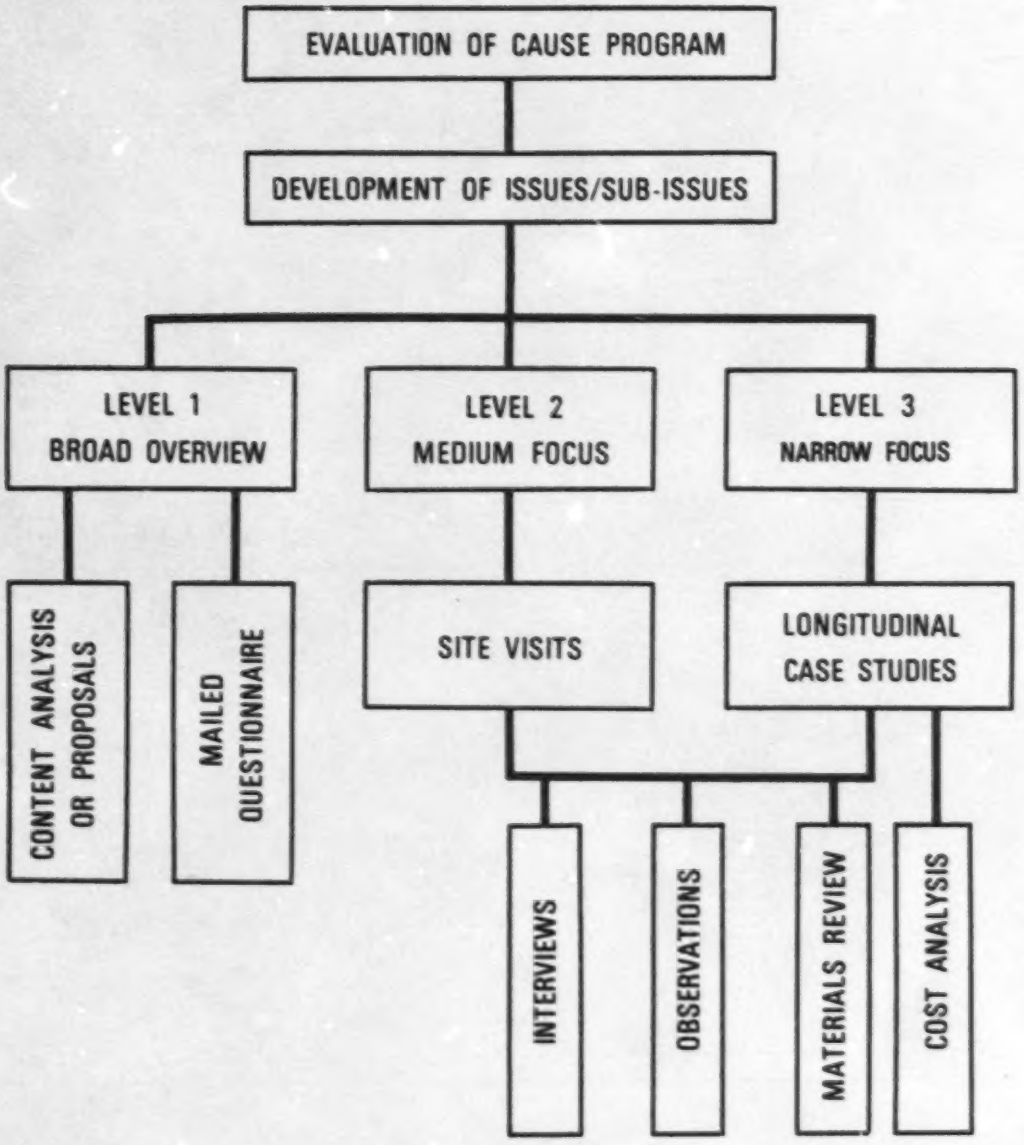

Figure 1. Profile of the Evaluation Design

The narrow focus evaluation. This component of the evaluation provided an in-depth view of eight CAUSE projects with multiple site visits to each. A detailed understanding of these projects was made possible by this approach. The cost issue was explored in connection with these case studies.

A SUMMARY OF THE CONCLUSIONS

Introduction

Chapter Three of Volume I of the evaluation report presents the evaluation's overall conclusions. The conclusions are organized around the issues whose choice and definition are explained in Chapter Two. Various conclusions are presented relevant to each issue. An explanation of each conclusion is provided along with a series of references to some of the specific evaluation findings which led to the conclusion. The reader is encouraged to use these references as a bridge to the more detailed findings and evidence presented in Volumes II and III.

The contents of Chapter Three represent the ultimate level of refinement for the evidence gathered through the evaluation's various activities. Other analyses of findings are presented in the first chapters of Volumes II and III, but these analyses are solely at the level of the study's narrow and medium, or broad focus methods respectively. The conclusions presented here and in Chapter Three are based on all aspects of the evaluation.

The Conclusions

The conclusions are organized around the first five issues of the evaluation. Issue Six, relating to recommendations for NSF policy, is discussed separately in Volume I and in this executive summary.

The following are the major conclusions of the evaluation of CAUSE. Fuller explanation and discussion of each conclusion are available in Chapter Three of Volume I.

Conclusion 1.1: Most CAUSE projects would not have occurred without CAUSE funding.

This is perhaps the most basic conclusion of the evaluation. It confirms the fact that the NSF funds are necessary to establish

projects of the type sponsored by CAUSE. (This, of course, implies nothing about the importance or appropriateness of the projects themselves, which will be dealt with in later conclusions.)

Approximately half of the project directors surveyed and visited reported that they would have "given up on their projects for lack of funds" if CAUSE money had not been available. The reports of the site visitors confirm this perception. It appears, further, that those who would have proceeded without CAUSE funds would have had to do so at an extremely reduced capacity and in almost all cases with a drastically different project.

Conclusion 1.2: CAUSE Projects Fill Needs Perceived as Important within Institutions which Receive the Grants

The CAUSE program stresses a focus on locally defined needs as opposed to more general, nationally defined needs. The hope expressed in the legislation is that the CAUSE program ". . . will permit departments and institutions to develop their own approaches to science teaching." The CAUSE program guidelines require a statement from the institutional administration (usually signed by the president or academic vice-president) describing the project's relationship to institutional goals and stating the institution's commitment to and support of the project's implementation and post-grant continuation. This description and justification of local needs is seen as one means of insuring the necessary institutional support for project implementation and the eventual continuation of project improvements in post-grant years.

Conclusion 2.1: CAUSE Projects are Being Implemented as Proposed.

The relationship between the project as described in the proposal and the project as implemented generally was an initial focus of the site visitors, not as an assessment of compliance but as a means of becoming quickly acquainted with the nature of the ongoing project. The survey of project directors also asked several questions on this point. In the opinion of the project directors as well as the site visitors, there was a very close match between projects as proposed and projects as implemented.

This generalization, however, should be qualified on two counts. First, there frequently were some variations from original plans, usually in terms of emphasis and occasionally through the dropping of one or two original objectives. Sometimes this was done through a formal amendment to the grant, but more often it simply occurred during project implementation. The variations were rarely significant in terms of the project's overall goals and often represented reasonable judgments on the part of the project director. The need for modifications usually resulted either from an initial lack of understanding of the resources necessary to carry out the proposed tasks (this was especially true with respect to materials and curriculum design activities) or from a

mid-project decision to de-emphasize the project's relatively unsuccessful aspects and emphasize its more successful aspects. Occasionally changes had to be made due to changes in project personnel.

Conclusion 2.2: CAUSE Projects Serve as Catalysts in Focusing, Motivating and Coordinating Instructional Improvement Activities of Science Faculty.

High quality projects are characterized by high quality project staff. While these people generally were present at the institution before the award of the grant, due to various institutional constraints they may not have worked together previously on a major instructional improvement effort. The CAUSE project acts as a catalyst and overcomes some of these real or perceived constraints and brings these people together. Typical constraints which CAUSE funding can help to overcome include lack of time, opportunity (and often precedent) to work with people other than immediate colleagues, and a general lack of substantive support for the improvement of instruction within the institution.

Conclusion 2.3: Projects Are Generally Adequately Managed, but Project Directors Often Do Not Have Access to Areas of Expertise Important to Project Implementation.

While it was found that most projects are achieving (sometimes surpassing) their proposed objectives, it also is the case that these achievements are frequently limited by or require more effort than necessary due to a lack of the required expertise. Generally, this lack of expertise is not in the area of project management since project directors tend to be experienced faculty who have the respect of their colleagues and are effective leaders. Instead, the lack of expertise generally involves some specific activity of the project itself. Such deficiencies were often recognized in the proposal and plans were made to compensate for the missing expertise by hiring consultants. Sometimes, however, the need for certain kinds of expertise had not been adequately recognized in planning the project.

Conclusion 2.4: Effective Project Directors Tend to Possess Several Common Characteristics.

In most cases, project directors who are effective are senior faculty members and had primary responsibility for writing the proposal. Their involvement in the proposal writing meant that they were the ones primarily responsible for formulating project objectives and implementation plans. Thus they had thorough knowledge and understanding of the rationale of project activities from the inception of project implementation. In most successful projects which span departments or divisions of the institution, the project directors hold administrative positions such as department chairperson. Presumably, senior faculty are more able

than junior faculty to weather the political implications of administering across organizational units and are in addition less susceptible to "publish or perish" pressures.

Good project directors provide strong personal leadership and are innovators at their institutions. Generally they are among the first at their institutions to urge adoption of local innovative activities, typically in the guise of a CAUSE project. Most are well respected among colleagues and administrators and set examples of hard work and enthusiasm for the project. A related characteristic is that effective project directors are frequently adept at handling institutional politics. This appears to be most important when projects cross organizational lines within the institution.

Conclusion 2.5: The Use of Release Time Is a Critical Factor in the Efficient and Effective Use of CAUSE Dollars.

The use of release time appears to be of extreme importance in the successful completion of CAUSE projects. In implementing the projects, however, it is sometimes very difficult to allocate or administer release time effectively. Problems involving the effective allocation of release time generally stem from a number of sources including the nature and size of the institution, the accuracy of the planned-for level of effort, institutional policies, and the willingness of institutional administrators to live up to commitments made. For some projects, the timing of release time and the intensity of project activities proved to be a problem.

Conclusion 2.6: Institutional Support Is Critical to Successful Project Implementation

Horizontal and vertical support for CAUSE projects appears to be generally adequate for project success. However, there does seem to be definite room for improvement, and for some projects lack of support is a serious problem. This lack of support is sometimes due to a lack of skills, abilities, and political power of the project director and project faculty. At other times it is due to a lack of a clear understanding and definition of what institutional needs are being served by the project and why they are of high priority.

Conclusion 2.7: CAUSE Projects Often Represent Innovations Within Their Respective Institutions Which Are Not Usually Innovations to Science Education.

The large majority of project directors (94%) responding to the first survey reported that their projects were either very innovative (52%) or somewhat innovative (42%) as compared to the regular activities of the department(s) involved in CAUSE. Observations of the site visitors confirmed this report. Project directors are in general viewed as innovators within their departments and most often the project activities are unlike activities

occurring in related departments.

In general, however, the projects cannot be characterized as innovative with respect to science education as a whole since most of the projects we visited had counterparts occurring somewhere else in the country under the auspices of the CAUSE program. In fact, there are strong similarities among projects even within the sample of 25 we observed. Although certain aspects of some of the projects do represent a unique approach or a unique application of a certain technology, there tends to be a substantial overlap among projects with respect to the problems grappled with and in the solutions found.

It is not necessary to be innovative nationally to be successful. It is not even necessary to be innovative locally if the needs are legitimate and of high priority. It is important to recognize, however, that many projects that are innovative locally could benefit substantially from investigating the present and previous efforts of others attempting similar projects so that something might be learned from the successes and failures of others.

Conclusion 2.8: Comprehensive Projects Have Stronger Potential for Overall Lasting Improvements to Undergraduate Science Education.

In reviewing project implementation and impact at the 25 projects we visited, one overall theme emerged: the best projects were those which were most comprehensive. The CAUSE program guidelines encourage the conduct of comprehensive projects. Such projects are described as "those which are broader and more integrated, and which include a set of coordinated activities".

Conclusion 3.1: Science Education Resources Have Been Improved.

CAUSE projects generally have strengthened science education resources with respect to instructional materials, laboratory and instructional equipment, instructional facilities, and the development of faculty skills in instructionally related areas. The improvements wrought by the projects are likely to provide in most cases, long-term benefits to institutions in terms of their capability to provide quality science programs. Particularly in those projects which have involved the acquisition of equipment and/or the acquisition/renovation of institutional facilities, more or less permanent improvement in science education resources have been made. Of course, there are exceptions, especially in those cases where project activities have primarily consisted of "one time" occurrences and where there appears to be little institutional support for the continued pursuit of project goals.

Conclusion 3.2: Institutional Capabilities for Self-Assessment, Management and Evaluation Have Not Been Substantially Changed.

One of the primary charges of the CAUSE program is to improve the capabilities of institutions to perform self-assessment, management, and evaluation. On the basis of the evidence collected during the course of this study, however, it appears that this goal has fallen short of the mark. This is not to say that the CAUSE projects have not had some impact on the capabilities of individuals within the institutions with respect to these areas. Indeed, many projects have provided a powerful means of professional development for faculty (especially project directors), particularly in the area of management.

Conclusion 3.3: The Quality of Science Instruction Has Been Improved Within Most Institutions Funded by CAUSE

The strongest evidence for the improvement of the quality of instruction is the expansion of instructional opportunities for students. Many of these opportunities have been designed into courses as required activities and many others have been designed to be supplementary to existing course materials and used at the students' option. In many cases the CAUSE projects have made available educational experiences that simply were not available previously (e.g., through the acquisition and development of laboratory facilities, both self-study and traditional, computer hardware and software, revised curricula and the like). Although instructional materials prepared under CAUSE grants vary widely in terms of normal instructional design criteria (clarity, organization, specification of goals and objectives, readability, appropriate use of the medium, etc.), most are being used by faculty and students who generally report them to be useful.

Conclusion 3.4: The Direct Impact of CAUSE Projects on Students Cannot Generally Be Documented.

Very little evidence exists at most CAUSE projects which shows a direct impact of project activities on students' knowledge, attitudes and behaviors. When such evidence does exist, as in the form of test scores or feedback on student questionnaires, it is difficult if not impossible to determine from available data whether or not the impact is more, less or different from impacts that could have been expected from participation in non-CAUSE or pre-CAUSE educational experiences.

Conclusion 3.5: A Range of Secondary and Unintended Effects Have Occurred as a Result of the CAUSE Projects.

Several outcomes of the CAUSE projects have occurred which might best be classified as secondary or unintended since they are not within the scope of the original intentions or goals of the project. Nevertheless, these effects probably have important

implications for the quality of the science programs at the institutions at which they have occurred.

Conclusion 4.1: CAUSE Has Resulted in Increased Awareness of Evaluation in Undergraduate Science Education.

A major goal of the CAUSE program is to "increase institutions' capability for self-assessment. . . and evaluation of their science programs". The present study found that the CAUSE program has resulted in an increased awareness of the role of evaluation in improving undergrate science education programs. While an increased awareness is short of an actual increase in capability and application, increased awareness is an important initial step to increased capability and usage.

Conclusion 4.2: There Is Widespread Uncertainty Among Project Staff About the Nature and Purpose of Evaluation.

While many project directors, in fact the vast majority, agree with statements from the survey like, "It is important that CAUSE guidelines require evaluation as part of projects", and "Evaluation is important at our institution in monitoring the effectiveness of projects of this type", there is also a strongly held feeling that precious project resources should not be used for evaluation when they are needed for implementation activities. The agreement with statements affirming the importance of evaluation suggests that some project directors are likely to verbally support evaluation while also feeling that evaluation is the least important of all project priorities. Consequently, there is a lack of clarity and focus in evaluation activities at CAUSE institutions. Sometimes the evaluation proposed initially has not been done or has been modified. Sometimes data are not utilized effectively.

Conclusion 4.3: Evaluations as Implemented Vary Considerably in Substance from Evaluations as Proposed.

The majority of project directors responding to the survey reported that evaluation plans were being carried out as proposed. However, survey results also showed evaluation to be one of the activities which, in practice, most frequently deviated from the proposal's plans. This finding was generally confirmed during the site visits: evaluation plans were often being followed in name only with relatively little attention to the role evaluation activities could play in conducting or improving project activities.

Conclusion 4.4: CAUSE Has Had Little Impact on Institutions' Capabilities for Self-Assessment.

Because evaluation has not played an important or prominent role in the individual projects and has had little effect on them, it has not been possible for the CAUSE projects to have any real impact on an institution's capability for self-assessment or

evaluation of their science education programs. The project directors who already knew something about evaluation pretty much administered the evaluation activities themselves, resulting in no institutional change. Those who knew little about evaluation either retained the services of an evaluation consultant or an expert from a relevant science discipline from within the institution or from some other institution. In either of these cases very little interaction occurred between evaluator and project staff which would increase the staff's capabilities in evaluation. In the case of evaluation consultants, efforts were focused on the collection of data. In the case of discipline experts, efforts focused on a review of course content.

Conclusion 4.5: Evaluation Has the Potential to Improve CAUSE Projects in Important Ways.

The improvement-oriented or formative role of evaluation has the most potential for improving projects in that it relies heavily on the already existing expertise of project directors and staff and can have a direct impact on the achievement of their own objectives. While there are specific data collection and analysis techniques useful to formative evaluation, we saw several instances in which project staff with no training in evaluation were conducting extremely useful formative evaluations. The evaluation activities, sometimes not labeled as such, were characterized by explicit consideration of desired outcomes and careful observation of interim products (and the initial use of these products) to determine the extent to which the outcomes were being achieved. Sometimes these observations were formal and sometimes they were informal. However, they were always conscious of and directed toward collecting information useful to the improvement of project activities or outcomes.

Conclusion 5.1: Most CAUSE Projects Support Design and Implementation Expenditures for Instructional Improvements with Low Recurring Costs for Post-Grant Continuation of the Improvements.

Overall we found that CAUSE funds generally have supported the design and investment expenditures necessary for capital improvement projects. Whether they have been primarily instructional development efforts or additions to equipment or facilities, most projects have represented a one-time allocation of resources to accomplish a specific kind of improvement that would continue to provide benefits in the future with little or no marginal recurring costs for their operation.

Conclusion 5.2: Institutional and Personal Contributions to CAUSE Projects Almost Always Exceed the Contributions Originally Proposed.

In most cases the local CAUSE projects have served to coalesce and focus local resources for the improvement of science education beyond the extent originally proposed. This was observed and

documented most clearly in the cost analyses at the institutions described in the eight case studies, but it was frequently noted by site visitors to the remaining 17 institutions as well. Sometimes the additional institutional contributions have been quite obvious as when the institution covered the extra cost of additional or higher quality equipment than originally proposed. At other times these additional contributions have been less obvious, although just as real, as when the presence of the project has served as a means of attracting a variety of other institutional resources in the form of donated administrative time, or the use of additional university facilities or services for project-related purposes. The increase in visibility and reputation of a given department has also sometimes been reported as providing additional leverage to local science departments during institutional budget negotiations. Substantial personnel resources have also been donated to the projects, most often by individual project faculty, in the form of evening and weekend hours.

RECOMMENDATIONS

Introduction

A question asked of project directors and staff during the course of the various site visits and also on the two surveys was "If you had one thing to recommend to the National Science Foundation regarding the CAUSE program, what would it be?". This question was often asked among the site visitors themselves during the course of the evaluation, and was asked again in writing of each of the site visitors before final deliberations regarding the conclusions and recommendations were conducted. Many more recommendations have been suggested over the course of the evaluation, most of which have been discussed or at least implied in the various levels of analysis included in Volumes II and III of this report. The recommendations presented here are those which emerged most frequently during these discussions and which appear to have the greatest potential for strengthening the CAUSE program.

Recommendation One: The CAUSE Program Should Be Continued and Strengthened.

The CAUSE program has been effective in improving the nation's science education resources. Institutional needs for improvement of instruction in science education are real and institutional budgets are unable to support the initiation of the sort of comprehensive projects brought about by the CAUSE program. Projects have been effectively implemented and are meeting institutional

needs as perceived by local science faculties. Through the CAUSE program's requirement of matching funds as well as through the catalytic effect of many funded projects within their respective institutions, the CAUSE program has encouraged the targeting of institutional and human resources toward the improvement of undergraduate science education. The CAUSE program is effective.

Although the basic organization and intent of the CAUSE program is sound and no significant weaknesses have been identified as inherent to its general approach, we believe that the CAUSE program can be strengthened significantly through an increase in emphasis in a number of critical areas.

Recommendation Two: The CAUSE Program Staff Should Be Enlarged, or Other Means of Providing Additional Personnel Support to the CAUSE Program Should be Provided.

There were very few complaints voiced by project directors about NSF's administration of the CAUSE program. Quite the contrary, comments on the surveys as well as those made during site visits were quite positive. Although contact between CAUSE program staff and individual projects was infrequent, the contacts that did occur were well regarded.

However, it was clear from observations made during the site visits that a number of problems could have been avoided and projects often could have been more effectively implemented had the expertise of fellow scientists experienced in the improvement of instruction through large-scale development efforts been available. We feel the advice and support that is presently being given to project directors by program staff is appropriate and useful and that an increase of such advice and support would result in a more effective CAUSE program.

Recommendation Three: Project Directors Should Be Encouraged and Assisted in Obtaining Specialized Expertise When Needed.

There are a number of specific areas of expertise useful to directors of large-scale instructional improvement projects. Comments made by project staff on survey forms and during the course of site visits as well as observations made by the site visitors themselves indicate that expertise in many areas is often unavailable to given projects. Specific types of expertise noted to be lacking most often include expertise in evaluation, instructional development, project management, hardware acquisition and instructional computer programming.

Possible ways in which obtaining assistance in these areas could be encouraged, when the need exists, include suggesting the use of outside experts through program guidelines or during negotiations, supplying project directors with lists of sources of available expertise in each of these areas, and sponsoring targeted workshops for project directors needing assistance.

Recommendation Four: Communications and Collaboration Across the Country Among Project Staff and Others Involved in and/or Experienced with Similar Instructional Improvement Efforts Should Be Encouraged and Supported.

Improvements in the communication and collaboration between CAUSE projects could greatly improve the efficiency and effectiveness of many projects. Among the 25 projects visited as part of this study, many were quite similar in nature and intent. Many more similarities undoubtedly exist among all CAUSE-funded projects, not to mention other instructional improvement efforts not funded by CAUSE. As the site visitors went from project to project, they frequently saw project staff addressing and solving many of the same problems, but usually only after considerable time and effort had been expended. In those few projects where project staff had access to similar projects elsewhere, they seemed to benefit greatly from the experience of others. Unfortunately, most project directors of other projects similar to their own have little means of access to those projects, or do not understand how their project might benefit from another's experience.

This situation exists in spite of efforts by the CAUSE program to disseminate information on funded projects and to bring the project directors together to meet one another. While these efforts are appropriate, they are insufficient. The kind of information that most project directors would benefit from has more to do with the process of conducting project activities than with the products of those activities. New project directors need to hear the stories of how other projects have been conducted. They need to be able to talk to someone about the minutiae of project activities.

It seems clear that the more that can be done to foster communication and collaboration among CAUSE project directors the better. In addition to the CAUSE program's existing efforts in this area, it is recommended that CAUSE encourage or foster further opportunities for project directors to meet and talk with one another. Specifically, the role of the present project directors' meeting should be clarified and extended. All project directors should attend one such meeting a year. This meeting should be longer than it is at present, provide more opportunity for project director to project director interaction, and (to accommodate the needs of new projects) should be held in the summer rather than in the fall. The conduct of such a meeting could represent an unrealistic burden for CAUSE program staff; however, the meeting could be organized and largely conducted by any of a number of external groups or organizations familiar with the CAUSE program. Much of the cost of these meetings would be underwritten by stipulated allocations in project budgets. Furthermore, it is recommended that proposal guidelines stress the desirability of establishing budget allocations for other kinds of project-related professional development activities. In addition to the project

director meetings, most projects would benefit from opportunities for their faculty to attend workshops, professional association meetings and other events related to their projects' activities.

A number of other steps could be taken as well to further project directors' access to information on the process of conducting CAUSE projects. Careful descriptions of projects, such as the case studies presented in Volume II of this report, should be disseminated to the project directors. Proposals, interim reports and evaluation findings of selected projects could be gathered together in a kind of lending library for project directors. (It would also clarify the role of project interim reports and final reports if project directors understood that these reports were being written to inform future project directors.)

Other ideas along these lines can be generated and these need more refinement. The important thing to understand is that to be successful most CAUSE projects require some professional development of project staff in such areas as instructional development, instructional technology, and so on. The CAUSE program should devote further attention to facilitating the professional development aspects of the projects in order to maximize their efficiency and effectiveness.

Recommendation Five: A Project Directors' Reference Manual Should Be Created to Provide Support and Direction to Project Staff, Particularly in the Areas of Project Management, Evaluation and Instructional Design.

There are a sufficient number of problems faced in common by most project directors and staff to justify the creation of a reference manual describing these potential problems and alternate means of attacking them. Included in such a manual would be descriptions of various management, evaluation and instructional design strategies used by successful project directors, and criteria to aid in the selection of the appropriate strategy for a given situation. Of particular use would be hints, guidelines, and forms useful for the monitoring and control of project activities. The selection and use of outside experts would also be covered, as would be hints on the successful use of formative evaluation strategies. References to additional sources of information would also be included. The availability of such a manual, which would rely primarily on the experience of project directors of past CAUSE programs, would greatly decrease the present problems due to each project tending to start anew with little awareness of the progress already made by others.

Recommendation Six: The CAUSE Program's Present Emphasis on Local Need and Institutional Support Should be Continued, If Not Increased.

Effective CAUSE projects are based on high priority local needs. Although this statement is somewhat obvious, its implications for the planning and implementing of projects are not. It

is relatively easy to construct a statement of institutional need that does not contradict the institution's general goals and which directly supports whatever instructional improvement project a creative faculty member would like to implement. However, it is extremely difficult to identify, clarify and articulate a consensus on local instructional needs in a way that drives and focuses project planning, design, implementation and evaluation. However, without a clear, common and meaningful understanding of what needs are to be filled and exactly how project activities are to meet those needs, the filling of the needs will depend more on chance than on design. Because it is so easy for institutional administration and project staff to climb aboard the bandwagon of an intuitively appealing solution and so difficult to clearly and meaningfully articulate the concept of high priority institutional need, it is critical that project staff be encouraged and assisted with respect to recognizing the importance of local institutional needs as the driving force of their projects.

A number of specific actions can be taken to make the present emphasis on institutional needs more meaningful to project planners and implementers. The statement of institutional support should represent the commitment not only of the institution's highest levels of administration, as is presently the case, but of the department chair(s) and dean(s) levels as well. This statement of commitment should explicitly define the specific needs to be addressed by the project and should describe the institution's specific commitment to the project in terms of how faculty time will be reallocated, what responsibilities participating faculty will be released from (and how those responsibilities will be covered), and the incentives the institution will provide participating faculty to enhance their continued interest and participation in the project. Evidence of individual faculty members' personal and professional commitment to the project should also be emphasized in project proposals.

Recommendation Seven: A Greater Emphasis Must Be Placed on the Clarification and Improvement of Proposals Once the Proposal Review Process Is Completed but Before the Grants Are Formally Awarded.

Some amount of negotiation between CAUSE program staff and selected grantees presently occurs as part of the formal award procedure and the modifications to original proposals recommended by proposal reviewers and CAUSE staff appear to have been generally sound. (Although pre-award negotiations were not a formal focus of our evaluation, documentation of these negotiations was often reviewed by site visitors.) However, we believe that it is at this point in the project development process that NSF has the greatest power to positively effect the quality of CAUSE projects. Project staff will be more strongly motivated to put additional time and effort into the improvement of proposals because they know the probability of award is great. This is also an opportune time to require the institution's administrators and department faculty to

become more precise about the nature of their commitment. In particular, it would be an ideal time to fully explicate the issues of release time, management and logistics, and evaluation.

Since the recommendations of the proposal review teams are an important source of information for CAUSE program staff during the pre-award process, it is important that each review team include at least one person knowledgeable and experienced in comprehensive instructional improvement efforts in higher education. We believe a number of problems within specific projects could have been avoided had they been identified during the proposal review process.

Recommendation Eight: More Emphasis Should Be Placed on the Relationship Between Development and Operation Costs Within Proposed Projects.

The distinction between development costs (i.e., the costs required to bring about an instructional improvement) and recurring operation costs (i.e., the costs required to maintain an instructional improvement) is not usually addressed in project proposals, nor does it appear to be one consciously made by many project directors. However, the formal consideration of the cost structures of the eight case study sites as well as a more informal consideration of costs within each of the other sites visited strongly suggests that the distinction is extremely important in CAUSE, particularly with respect to its bearing on the post-grant maintenance of projects. The costs of most of the projects visited were primarily development costs. We believe that most of the instructional improvements brought about by these projects will continue to be maintained by their institutions upon completion of the grant. The relatively high recurring operation costs of a few of the projects raised some doubts as to these projects' continued viability within their respective institutions in post-grant years. During the solicitation and award process an explicit emphasis should be placed on determining the proportion of the project which is a recurring operation cost. Those projects with a high portion of recurring operation costs should be required to carefully justify the projects' plans in terms of long-term benefit to the institution and/or maintenance of the projects' improvements. The commitment and ability of the institution to continue the proposed instructional improvement in post-grant years should be examined very closely by the proposal reviewers and the CAUSE program staff.

Summary

The CAUSE program is meeting extremely important institutional needs for improved science education resources. Some strengthening of the program, as suggested by the above recommendations, would enhance the implementation and increase the impact of local projects.